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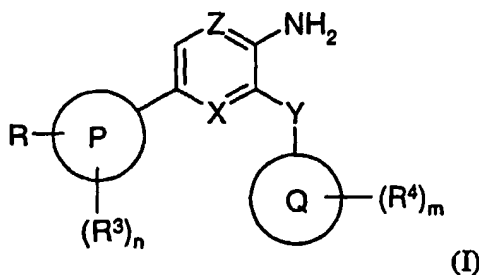
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(54) Title: NOBEL COMPOUNDS HAVING SELECTIVE INHIBITING EFFECT AT GSK3



pharmaceutical formulations containing said therapeutically active compounds and to the use of said active compounds in therapy.

(57) Abstract: The present invention relates to new compounds of formula (I) wherein: Z is N and X is CH or N; Y is CONR<sup>5</sup>; P is phenyl or a 5 or 6 membered heteroaromatic ring containing one or more heteroatoms selected from N, O or S; Q is phenyl or a 5 or 6 membered aromatic heterocyclic ring containing one or more nitrogen atoms; R is C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup> or C<sub>1-6</sub>alkylazetidide; R<sup>10</sup> is hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl or C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>; R<sup>11</sup> is C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl or C<sub>0-6</sub>alkylheterocycloalkyl; as a free base or a pharmaceutically acceptable salt, solvate or solvate of salt thereof, a process for their preparation and new intermediates used therein,

Novel compounds having selective inhibiting effect at GSK3.

## FIELD OF THE INVENTION

5 The present invention relates to new compounds of formula I, as a free base or a pharmaceutically acceptable salt, solvate or solvate of salt thereof, to pharmaceutical formulations containing said compounds and to the use of said compounds in therapy. The present invention further relates to a process for the preparation of compounds of formula I and to new intermediates used therein.

10

## BACKGROUND OF THE INVENTION

Glycogen synthase kinase 3 (GSK3) is a serine / threonine protein kinase composed of two  
15 isoforms ( $\alpha$  and  $\beta$ ), which are encoded by distinct genes but are highly homologous within the catalytic domain. GSK3 is highly expressed in the central and peripheral nervous system. GSK3 phosphorylates several substrates including tau,  $\beta$ -catenin, glycogen synthase, pyruvate dehydrogenase and elongation initiation factor 2b (eIF2b). Insulin and growth factors activate protein kinase B, which phosphorylates GSK3 on serine 9 residue  
20 and inactivates it.

### *Alzheimer's Disease (AD) dementias, and tauopathies.*

AD is characterized by cognitive decline, cholinergic dysfunction and neuronal death, neurofibrillary tangles and senile plaques consisting of amyloid- $\beta$  deposits. The sequence  
25 of these events in AD is unclear, but is believed to be related. Glycogen synthase kinase 3 $\beta$  (GSK3 $\beta$ ) or Tau ( $\tau$ ) phosphorylating kinase selectively phosphorylates the microtubule associated protein  $\tau$  in neurons at sites that are hyperphosphorylated in AD brains. Hyperphosphorylated protein  $\tau$  has lower affinity for microtubules and accumulates as paired helical filaments, which are the main components that constitute neurofibrillary  
30 tangles and neuropil threads in AD brains. This results in depolymerization of microtubules, which leads to dying back of axons and neuritic dystrophy. Neurofibrillary tangles are consistently found in diseases such as AD, amyotrophic lateral sclerosis,

parkinsonism-dementia of Gaum, corticobasal degeneration, dementia pugilistica and head trauma, Down's syndrome, postencephalatic parkinsonism, progressive supranuclear palsy, Niemann-Pick's Disease and Pick's Disease. Addition of amyloid- $\beta$  to primary hippocampal cultures results in hyperphosphorylation of  $\tau$  and a paired helical filaments-like state via induction of GSK3 $\beta$  activity, followed by disruption of axonal transport and neuronal death (Imahori and Uchida., J. Biochem 121:179-188, 1997). GSK3 $\beta$  preferentially labels neurofibrillary tangles and has been shown to be active in pre-tangle neurons in AD brains. GSK3 protein levels are also increased by 50% in brain tissue from AD patients. Furthermore, GSK3 $\beta$  phosphorylates pyruvate dehydrogenase, a key enzyme in the glycolytic pathway and prevents the conversion of pyruvate to acetyl-Co-A (Hoshi et al., PNAS 93:2719-2723, 1996). Acetyl-Co-A is critical for the synthesis of acetylcholine, a neurotransmitter with cognitive functions. Thus, GSK3 $\beta$  inhibition may have beneficial effects in progression as well as the cognitive deficits associated with Alzheimer's disease and other above-referred to diseases.

#### *Chronic and Acute Neurodegenerative Diseases.*

Growth factor mediated activation of the PI3K /Akt pathway has been shown to play a key role in neuronal survival. The activation of this pathway results in GSK3 $\beta$  inhibition. Recent studies (Bhat et. al., PNAS 97:11074-11079 (2000)) indicate that GSK3 $\beta$  activity is increased in cellular and animal models of neurodegeneration such as cerebral ischemia or after growth factor deprivation. For example, the active site phosphorylation was increased in neurons vulnerable to apoptosis, a type of cell death commonly thought to occur in chronic and acute degenerative diseases such as Alzheimer's Disease, Parkinson's Disease, amyotrophic lateral sclerosis, Huntington's Disease and HIV dementia, ischemic stroke and head trauma. Lithium was neuroprotective in inhibiting apoptosis in cells and in the brain at doses that resulted in the inhibition of GSK3 $\beta$ . Thus GSK3 $\beta$  inhibitors could be useful in attenuating the course of neurodegenerative diseases.

#### *Bipolar Disorders (BD)*

Bipolar Disorders are characterised by manic episodes and depressive episodes. Lithium has been used to treat BD based on its mood stabilising effects. The disadvantage of

lithium is the narrow therapeutic window and the danger of overdosing that can lead to lithium intoxication. The recent discovery that lithium inhibits GSK3 at therapeutic concentrations has raised the possibility that this enzyme represents a key target of lithium's action in the brain (Stambolic et al., Curr. Biol. 6:1664-1668, 1996; Klein and Melton; PNAS 93:8455-8459, 1996). Inhibition of GSK3 $\beta$  may therefore be of therapeutic relevance in the treatment of BD as well as in AD patients that have affective disorders.

### *Schizophrenia*

GSK3 is involved in signal transduction cascades of multiple cellular processes, particularly during neural development. Kozlovsky et al (Am J Psychiatry 2000 May;157(5):831-3) found that GSK3 $\beta$  levels were 41% lower in the schizophrenic patients than in comparison subjects. This study indicates that schizophrenia involves neurodevelopmental pathology and that abnormal GSK3 regulation could play a role in schizophrenia. Furthermore, reduced  $\beta$ -catenin levels have been reported in patients exhibiting schizophrenia (Cotter et al., Neuroreport 9:1379-1383 (1998)).

### *Diabetes*

Insulin stimulates glycogen synthesis in skeletal muscles via the dephosphorylation and thus activation of glycogen synthase. Under resting conditions, GSK3 phosphorylates and inactivates glycogen synthase via dephosphorylation. GSK3 is also over-expressed in muscles from Type II diabetic patients (Nikoulina et al., Diabetes 2000 Feb;49(2):263-71). Inhibition of GSK3 increases the activity of glycogen synthase thereby decreasing glucose levels by its conversion to glycogen. GSK3 inhibition may therefore be of therapeutic relevance in the treatment of Type I and Type II diabetes and diabetic neuropathy.

### *Hair Loss*

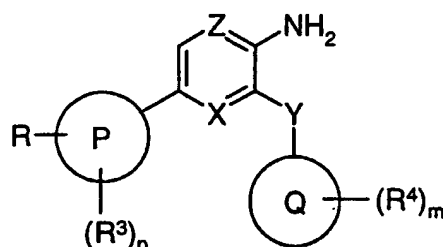
GSK3 phosphorylates and degrades  $\beta$ -catenin.  $\beta$ -catenin is an effector of the pathway for keratin synthesis.  $\beta$ -catenin stabilisation may lead to increase hair development. Mice expressing a stabilised  $\beta$ -catenin by mutation of sites phosphorylated by GSK3 undergo a process resembling de novo hair morphogenesis (Gat et al., Cell 1998 Nov 25;95 (5):605-14). The new follicles formed sebaceous glands and dermal papilla, normally established only in embryogenesis. Thus GSK3 inhibition may offer treatment for baldness.

*Oral contraceptives*

Vijayaraghavan et al. (Biol Reprod 2000 Jun; 62 (6):1647-54) reported that GSK3 is high in motile versus immotile sperm. Immunocytochemistry revealed that GSK3 is present in the flagellum and the anterior portion of the sperm head. These data suggest that GSK3 could be a key element underlying motility initiation in the epididymis and regulation of mature sperm function. Inhibitors of GSK3 could be useful as contraceptives for males.

## DISCLOSURE OF THE INVENTION

The object of the present invention is to provide compounds having a selective inhibiting effect at GSK3 as well as having a good bioavailability. Accordingly, the present invention provides a compound of the formula I



(I)

wherein:

Z is N;

Y is CONR<sup>5</sup>, NR<sup>5</sup>CO, SO<sub>2</sub>NR<sup>5</sup>, NR<sup>5</sup>SO<sub>2</sub>, CH<sub>2</sub>NR<sup>5</sup>, NR<sup>5</sup>CH<sub>2</sub>, NR<sup>5</sup>CONR<sup>5</sup>, C<sub>1-6</sub>alkylene, CH<sub>2</sub>CO, COCH<sub>2</sub>, CH=CH, OCH<sub>2</sub> or CH<sub>2</sub>O;

X is CH or N;

P is phenyl or a 5 or 6 membered heteroaromatic ring containing one or more heteroatoms independently selected from N, O or S and said phenyl ring or heteroaromatic ring may

optionally be fused with a 5 or 6 membered saturated, partially saturated or unsaturated ring containing one or more atoms selected from C, N, O or S;

Q is phenyl or a 5 or 6 membered heteroaromatic ring containing one or more nitrogen atoms and said phenyl ring or heteroaromatic ring may optionally be fused with a 5 or 6 membered saturated, partially saturated or unsaturated ring containing one or more atoms selected from C, N, O or S;

R is C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup> or C<sub>1-6</sub>alkylazetidine which azetidine ring may be optionally substituted by A;

R<sup>3</sup> and R<sup>4</sup> are independently selected from halo, nitro, CHO, C<sub>0-6</sub>alkylCN, OC<sub>1-6</sub>alkylCN, C<sub>0-6</sub>alkylOR<sup>6</sup>, OC<sub>1-6</sub>alkylOR<sup>6</sup>, fluoromethyl, difluoromethyl, trifluoromethyl, fluoromethoxy, difluoromethoxy, trifluoromethoxy, C<sub>0-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylOC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>OR<sup>7</sup>, C<sub>0-6</sub>alkylCO<sub>2</sub>R<sup>6</sup>, OC<sub>1-6</sub>alkylCO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(CO)R<sup>7</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(CO)R<sup>7</sup>, O(CO)NR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>(CO)OR<sup>7</sup>, NR<sup>6</sup>(CO)NR<sup>6</sup>R<sup>7</sup>, O(CO)OR<sup>6</sup>, O(CO)R<sup>6</sup>, C<sub>0-6</sub>alkylCOR<sup>6</sup>, OC<sub>1-6</sub>alkylCOR<sup>6</sup>, NR<sup>6</sup>(CO)(CO)R<sup>6</sup>, NR<sup>6</sup>(CO)(CO)NR<sup>6</sup>R<sup>7</sup>, SR<sup>6</sup>, C<sub>0-6</sub>alkyl(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(SO<sub>2</sub>)R<sup>7</sup>, OC<sub>0-6</sub>alkyl(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, C<sub>0-6</sub>alkyl(SO)NR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkyl(SO)NR<sup>6</sup>R<sup>7</sup>, SO<sub>3</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(SO)R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(SO)R<sup>7</sup>, OC<sub>0-6</sub>alkylSO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylSO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylSOR<sup>6</sup>, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl, wherein any C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl may be optionally substituted by one or more A;

m is 0, 1, 2, 3 or 4;

n is 0, 1, 2, 3 or 4;

R<sup>5</sup> is hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl, C<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup> or C<sub>1-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>;

R<sup>6</sup> and R<sup>7</sup> are independently selected from hydrogen, C<sub>1-6</sub>alkyl, (CO)OR<sup>8</sup>, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl and C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>;

R<sup>6</sup> and R<sup>7</sup> may together form a substituted 5 or 6 membered heterocyclic ring containing one or more heteroatoms independently selected from N, O or S, which heterocyclic ring may be optionally substituted by A;

R<sup>8</sup> and R<sup>9</sup> are independently selected from hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl;

R<sup>8</sup> and R<sup>9</sup> may together form a 5 or 6 membered heterocyclic ring containing one or more heteroatoms independently selected from N, O or S, which heterocyclic ring may be

5 optionally substituted by A;

R<sup>10</sup> is hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl or C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>;

R<sup>11</sup> is C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl;

A is halo, nitro, CHO, CN, OR<sup>6</sup>, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl;

10 C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, fluoromethyl, difluoromethyl, trifluoromethyl, fluoromethoxy, difluoromethoxy, trifluoromethoxy, C<sub>0-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, CO<sub>2</sub>R<sup>8</sup>, CONR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>(CO)R<sup>6</sup>, O(CO)R<sup>6</sup>, COR<sup>6</sup>, SR<sup>6</sup>, (SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, (SO)NR<sup>6</sup>R<sup>7</sup>, SO<sub>3</sub>R<sup>6</sup>, SO<sub>2</sub>R<sup>6</sup> or SOR<sup>6</sup>;

as a free base or a pharmaceutically acceptable salt, solvate or solvate of salt thereof.

15

One aspect of the invention relates to compounds of formula I, wherein Z is N; Y is CONR<sup>5</sup>; X is N; P is phenyl; Q is a 6 membered heteroaromatic ring containing one nitrogen atom; R is C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup>; m is 0; n is 0; R<sup>5</sup> is hydrogen; R<sup>10</sup> is hydrogen or C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl; C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl or C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>; and R<sup>11</sup> is C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl.

20

In one embodiment of this aspect there are provided compounds of formula I, wherein C<sub>1-6</sub>alkyl in C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup> represents propyl; R<sup>10</sup> and R<sup>11</sup> represents cyclobutyl; and Q represents pyridin.

25

In another aspect of the invention the following compounds are provided:

3-Amino-6-{4-[3-(dicyclobutylamino)propyl]phenyl}-N-pyridin-3-ylpyrazine-2-carboxamide hydrochloride;

as a free base or an alternative pharmaceutically acceptable salt, solvate or solvate of salt thereof.

30

In yet another aspect of the invention the following compound, which is useful as intermediate in the preparation of compounds of formula I, is provided:

3-Amino-6-bromo-*N*-pyridin-3-ylpyrazine-2-carboxamide;  
as a free base, a salt, solvate or solvate of a salt thereof.

5

In yet another aspect of the invention the following compound, which is useful as intermediate in the preparation of compounds of formula I, is provided:

*N*-[3-(4-Bromophenyl)propyl]-*N,N*-dicyclobutylamine;  
as a free base, a salt, solvate or solvate of a salt thereof.

10

Listed below are definitions of various terms used in the specification and claims to describe the present invention.

15 For the avoidance of doubt it is to be understood that where in this specification a group is qualified by 'hereinbefore defined', 'defined hereinbefore', 'is as defined above' or 'are as defined above' the said group encompasses the first occurring and broadest definition as well as each and all of the preferred definitions for that group.

20 For the avoidance of doubt it is to be understood that in this specification 'C<sub>0-6</sub>' means a carbon group having 0, 1, 2, 3, 4, 5 or 6 carbon atoms.

In this specification, unless stated otherwise, the term "alkyl" includes both straight and branched chain alkyl groups. C<sub>1-6</sub>alkyl may be methyl, ethyl, n-propyl, i-propyl, n-butyl,  
25 i-butyl, s-butyl, t-butyl, n-pentyl, i-pentyl, t-pentyl, neo-pentyl, hexyl.

The term "alkoxy" as used herein, unless stated otherwise includes "alkyl"O groups in which "alkyl" is as hereinbefore defined. C<sub>1-5</sub>alkoxy may be methoxy, ethoxy, n-propoxy, i-propoxy, n-butoxy, i-butoxy, s-butoxy, t-butoxy, n-pentyloxy, i-pentyloxy, t-pentyloxy,  
30 neo-pentyloxy.

In this specification, unless stated otherwise, the term "alkenyl" includes both straight and branched chain alkenyl groups but references to individual alkenyl groups such as



2-butenyl is specific for the straight chain version only. Unless otherwise stated, the term "alkenyl" advantageously refers to chains with 2 to 5 carbon atoms, preferably 3 to 4 carbon atoms. Alkenyl may be, but are not limited to, vinyl, allyl, propenyl, i-propenyl, butenyl, i-butenyl, crotyl, pentenyl, i-pentenyl or hexenyl.

5 In this specification, unless stated otherwise, the term "alkynyl" includes both straight and branched chain alkynyl groups but references to individual alkynyl groups such as 2-butyne are specific for the straight chain version only. Unless otherwise stated, the term "alkynyl" advantageously refers to chains with 2 to 5 carbon atoms, preferably 3 to 4  
10 carbon atoms. Alkynyl may be, but are not limited to, ethynyl, propargyl, butynyl, i-butyne, pentynyl, i-pentynyl or hexynyl.

In this specification, unless stated otherwise, the terms "aryl" refers to an optionally substituted monocyclic or bicyclic hydrocarbon ring system containing at least one  
15 aromatic ring. The "aryl" may be fused with a C<sub>5-7</sub>cycloalkyl ring to form a bicyclic hydrocarbon ring system. Examples and suitable values of the term "aryl" are phenyl, naphthyl, indanyl or tetralinyl.

In this specification, unless stated otherwise, the terms "heteroaryl" and "5 or 6 membered  
20 heteroaromatic ring" containing one or more heteroatoms selected from N, O and S may be, but are not limited to, furyl, imidazolyl, isoxazolyl, isothiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, thiazolyl or thienyl

In this specification, unless stated otherwise, the term "5 or 6 membered saturated, partly  
25 saturated or unsaturated ring containing atoms independently selected from C, N, O or S" may be, but are not limited to, furyl, isoxazolyl, isothiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, thiazolyl, thienyl, imidazolyl, imidazolidinyl, imidazolinyl, morpholinyl, piperazinyl, piperidyl, piperidonyl, pyrazolidinyl, pyrazolinyl, pyrrolidinyl, pyrrolinyl, tetrahydropyranyl, thiomorpholinyl,  
30 cyclohexyl or cyclopentyl.

In this specification, unless stated otherwise, the term "5 or 6 membered heteroaromatic ring containing one or more heteroatoms independently selected from N, O, or S" may be, but are not limited to, furyl, isoxazolyl, isothiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, thiazolyl, thienyl or imidazolyl.

5

In this specification, unless stated otherwise, the term halogen may be fluorine, chlorine, bromine or iodine.

The present invention relates to the use of compounds of formula I as hereinbefore defined  
10 as well as to the salts thereof. Salts for use in pharmaceutical compositions will be pharmaceutically acceptable salts, but other salts may be useful in the production of the compounds of formula I.

Both organic and inorganic acids can be employed to form non-toxic pharmaceutically  
15 acceptable acid addition salts of the compounds of this invention. In addition, a suitable pharmaceutically acceptable salt of the compounds of the invention, which is sufficiently acidic is an alkali metal salt, an alkaline earth metal salt or a salt with an organic base, which affords a physiologically-acceptable cation.

20 Some compounds of formula I may have chiral centres and/or geometric isomeric centres (E- and Z- isomers), and it is to be understood that the invention encompasses all such diastereoisomers, optical and geometric isomers that possess GSK3 inhibitory activity.

It is to be understood that the present invention relates to any and all tautomeric forms of  
25 the compounds of formula I.

An object of the invention is to provide compounds of formula I for therapeutic use, especially compounds that are useful for the prevention and/or treatment of conditions associated with glycogen synthase kinase-3 (GSK3) in mammals including man.

30 Particularly, compounds of formula I exhibiting a selective affinity for GSK-3.

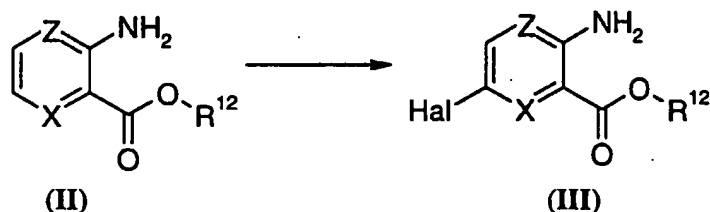
## METHODS OF PREPARATION

Another aspect of the present invention provides a process for preparing a compound of formula I as a free base or a pharmaceutically acceptable salt thereof.

Throughout the following description of such processes it is understood that, where appropriate, suitable protecting groups will be added to, and subsequently removed from, the various reactants and intermediates in a manner that will be readily understood by one skilled in the art of organic synthesis. Conventional procedures for using such protecting groups as well as examples of suitable protecting groups are described, for example, in "Protective Groups in Organic Synthesis" T.W. Green, P.G.M. Wuts, Wiley-Interscience, New York, 1999.

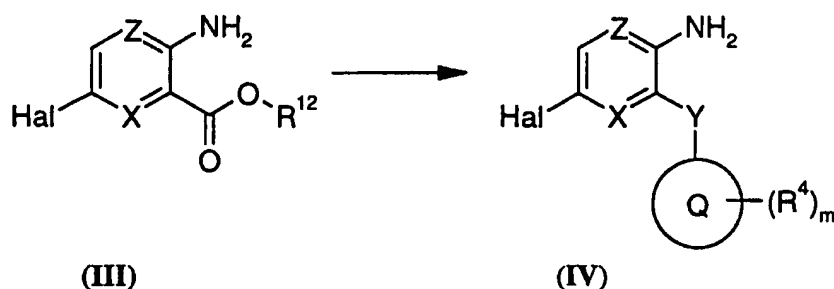
## Methods of preparation of intermediates

The process for the preparation of the intermediates, wherein Y, X, Z, P, Q, R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup>, R<sup>10</sup>, R<sup>11</sup>, R<sup>12</sup>, A, m and n are, unless specified otherwise, defined as in formula I, comprises of:

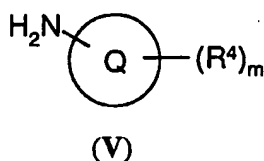


(i) halogenation of a compound of formula II, wherein Z is N and X are N or CH, R<sup>12</sup> is hydrogen, C<sub>1-6</sub>alkyl or when R<sup>12</sup> is hydrogen in the form of a salt such as a sodium salt, to obtain a compound of formula III, may be carried out using a suitable halogenating reagent such as iodine, bromine, chlorine, halide salts such as ICl, BrCl or HOCl or other suitable halogenation reagents such as *N*-bromosuccinimide or phosphorous tribromide.

The reaction may be catalysed by metals or acids such as Fe, Cu-salts, acetic acid or sulfuric acid or aided by oxidising agents such as nitric acid, hydrogen peroxide or sulfur trioxide. The reaction may be carried out in a suitable solvent such as water, acetic acid or chloroform at a temperature in the range of -70 °C to +100 °C.



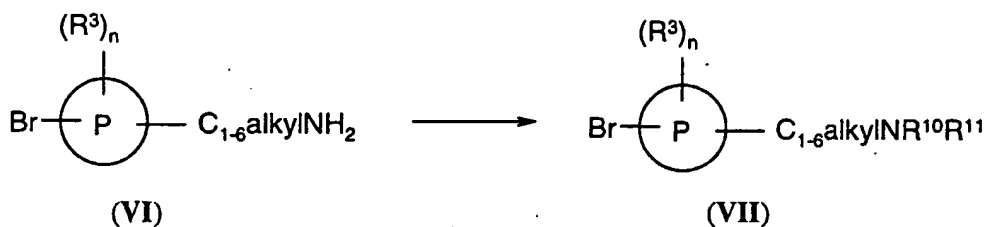
(ii) amidation of a compound of formula **III**, wherein Z is N and X are N or CH, R<sup>12</sup> is C<sub>1-6</sub>alkyl to obtain a compound of formula **IV**, wherein Y is CONR<sup>5</sup> may be carried out by treating a compound of formula **III** with the appropriate amine such as a compound of formula **V**,



wherein Q, R<sup>4</sup> and m is as defined above. The reaction may be performed neat or using a suitable solvent such as *N,N*-dimethylformamide, methylene chloride or ethyl acetate at a temperature ranging from -25 °C to +150 °C. The reaction may be aided by using a base such as potassium carbonate, triethylamine or 1,8-diazabicyclo[5.4.0]undec-7-ene or an acid such as trimethylaluminum or *p*-toulenesulfonic acid.

(iii) amidation of a compound of formula **III**, wherein R<sup>12</sup> is hydrogen, to obtain a compound of formula **IV**, wherein Y is CONR<sup>5</sup> and R<sup>4</sup> is a substituent that is not susceptible to certain coupling agents, may be performed by activation of a compound of formula **III** by treating the compound with coupling reagents such as 1,3-diisopropylcarbodiimide, 1-[3-(dimethylamino)propyl]-3-ethylcarbodiimide hydrochloride, 1,3-dicyclohexylcarbodiimide, O-(benzotriazol-1-yl)-*N, N, N', N'*-tetramethyluronium tetrafluoroborate, O-(benzotriazol-1-yl)-*N, N, N', N'*-tetramethyluronium hexafluorophosphate, 1,1'-carbonyldiimidazole or O-(7-azabenzotriazol-1-yl)-*N, N, N', N'*-

tetramethyluronium hexafluorophosphate where the reaction may be aided by the addition of 1-hydroxybenzotriazole hydrate, or using an acyl halide reagent such as cyanuric chloride, oxalyl chloride, thionyl chloride or bromotripyrrolidinophosphonium hexafluorophosphate, followed by treatment with the appropriate amine such as a compound of formula V, in a suitable solvent such as methylene chloride chloroform, acetonitrile or tetrahydrofuran and at a reaction temperature between 0 °C and reflux. The reaction may be aided by using a base such as potassium carbonate or a trialkyl amine e.g. triethyl amine or *N*-ethyl-*N,N*-diisopropyl amine



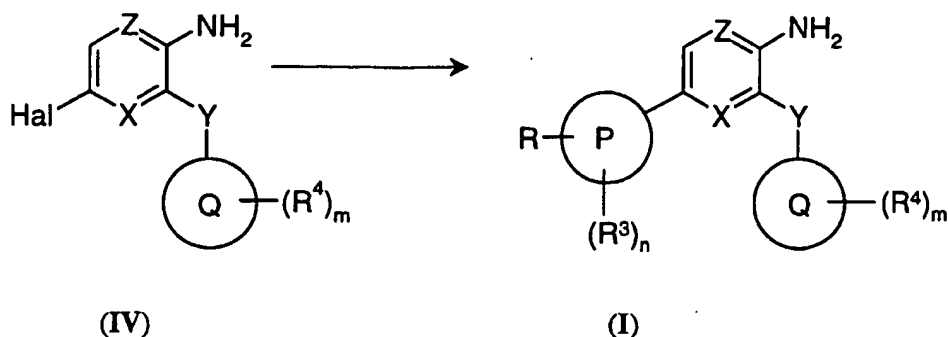
(iv) conversion of a compounds of formula VI, wherein P, R<sup>3</sup>, n and C<sub>1-6</sub>alkyl are as defined above, to a compound of formula VII, wherein P, R<sup>3</sup>, R<sup>10</sup>, R<sup>11</sup>, n and C<sub>1-6</sub>alkyl are as defined above, may be carried out by the reaction with a appropriate aldehyde (R<sup>10</sup>CHO and/or R<sup>11</sup>CHO) and/or a ketone (R<sup>10</sup>(CO)R<sup>11</sup>) in a suitable solvent such as methylene chloride, chloroform, dichloroethane or methanol in the precense of a suitable acid such as acetic acid followed by the addition of a suitable reducing agent such as sodium cyanoborohydride or sodium triacetoxo borohydride and at a reaction temperature between 0 °C and +50 °C.

#### Methods of preparation of end products

Another object of the invention are processes for the preparation of a compound of general formula I, wherein Y, X, Z, P, Q, R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup>, R<sup>10</sup>, R<sup>11</sup>, A, m and n are, unless specified otherwise, defined as in formula I, comprising of:

#### A

de-halogen coupling, wherein R<sup>3</sup> and R<sup>4</sup> are substituents that are not susceptible to certain agents in the reaction, of a compound of formula IV with a appropriate aryl species to give a compound of formula I:



- 5 Thus, the de-halogen coupling according to process A may be carried out by coupling of a compound of formula IV with an appropriate aryl boronic acid or a boronic ester. The reaction may be carried out using a suitable palladium catalyst such as Pd(PPh<sub>3</sub>)<sub>4</sub>, Pd(dppf)Cl<sub>2</sub> or Pd(OAc)<sub>2</sub> with or without a ligand such as P(*tert*-butyl)<sub>3</sub> or, 2-(dicyclohexylphosphino)biphenyl or a nickel catalyst such as nickel on charcoal or
- 10 Ni(dppe)Cl<sub>2</sub> together with Zn and sodium triphenylphosphinetrimetasulfonate. A suitable base such as an alkyl amine e.g. triethylamine, or potassium carbonate, sodium carbonate, sodium hydroxide or cesium fluoride may be used in the reaction, which is performed in the temperature range between +20 °C and +160 °C using an oil bath or in a microwave oven in a suitable solvent or solvent mixture such as toluene, tetrahydrofuran,
- 15 dimethoxyethane/water or *N,N*-dimethylformamide. The aryl boronic acid or a boronic ester may be formed from a compound of formula VII using a suitable base such as butyl lithium and a suitable boron compound such as trimethyl borate or triisopropyl borate. The reaction may be performed in an aprotic solvent e.g. tetrahydrofuran or hexane in a temperature range between -78 °C and +20 °C;
- 20 The hydrochloric salt of compound of formula I may be obtained from a compound of formula I by treatment with hydrochloric acid at a temperature range between 0 °C and +25 °C, in suitable solvent such as methylene chloride, tetrahydrofuran or methylene chloride/methanol mixture.

## WORKING EXAMPLES

## Example 1

**3-Amino-6-bromo-N-pyridin-3-ylpyrazine-2-carboxamide**

5 To 3-aminopyridine (10 g, 106 mmol) at 70 °C were added methyl 3-amino-6-bromo-2-pyrazinecarboxylate (1.0 g, 4.3 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (645 µL, 4.3 mmol). The reaction solution was stirred for 4 h, diluted with water (75 mL) and extracted with methylene chloride. The combined organic layers were washed with a saturated ammonium chloride solution, dried (MgSO<sub>4</sub>), filtered and evaporated in vacuo.

10 The crude product was purified on a silica gel column using methylene chloride/ethanol, (9:1), as the eluent to give 750 mg (59% yield) of the title compound as a yellow solid: <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ 9.50 (br s, 1 H), 8.82 (d, *J* = 3 Hz, 1 H), 8.43 (dd, *J* = 5 and 1 Hz, 1 H), 8.31 (s, 1 H), 8.23 (ddd, *J* = 8, 3 and 2 Hz, 1 H), 7.34 (dd, *J* = 8, 5 Hz, 1 H); MS (TSP) *m/z* 294 (M<sup>+</sup>+1).

15

## Example 2

**N-[3-(4-Bromophenyl)propyl]-N,N-dicyclobutylamine**

3-(4-Bromophenyl)propan-1-amine (0.50 g, 2.34 mmol; described in: Davies, R.V. et al. *J.Chem.Soc. Perkin Trans.1* 1977, 2357-2364), cyclobutanone (0.393 g, 5.61 mmol) and  
20 acetic acid (0.140 mL, 2.34 mmol) were mixed in dichloroethane (6 mL) and stirred for 30 min. Sodium triacetoxy borohydride was added and the reaction mixture was stirred for 15 h. The reaction was quenched with water (15 mL) and extracted with methylene chloride (50 mL). The organic phase was separated, dried and evaporated. Purification by column chromatography using methylene chloride to methylene chloride/methanol, (2:1), gradient  
25 as the eluent gave 0.32 g (42% yield) of the title compound as colorless oil: MS (ESI) *m/z* 322 and 324 (M<sup>+</sup>+1).

## Example 3

30 **3-Amino-6-{4-[3-(dicyclobutylamino)propyl]phenyl}-N-pyridin-3-ylpyrazine-2-carboxamide hydrochloride**

*n*-Butyllithium (0.97 mL, 1.55 mmol) was added dropwise over 20 min to a cooled

(-78 °C) solution of *N*-[3-(4-bromophenyl)propyl]-*N,N*-dicyclobutylamine (0.10 g, 0.31 mmol) and triisopropyl borate (0.21 mL, 0.93 mmol) in anhydrous tetrahydrofuran (2 mL) under a nitrogen atmosphere. The reaction mixture was stirred for 2 h at -78 °C. HCl (aq 3 M, 0.6 mL) was added to the reaction mixture and the mixture was allowed to warm to  
5 room temperature. Tetrahydrofuran (2 mL) was added, followed by sodium carbonate (1.1 g, 10.8 mmol), Pd(dppf)Cl<sub>2</sub> (0.010 g, 12.2 μmol) and 3-amino-6-bromo-*N*-pyridin-3-ylpyrazine-2-carboxamide (0.10 g, 0.34 mmol). The mixture was heated to 65 °C for 15 h. The solvent was removed and purification by column chromatography on silica using a gradient methylene chloride to methylene chloride/methanol, (2:1), as the eluent gave a  
10 yellow solid. The solid was dissolved in methylene chloride (10 mL) and 1 M HCl in diethyl ether was added while stirring. The formed yellow precipitate was filtered and dried to give 75 mg (53% yield) of the title compound as yellow solid: <sup>1</sup>H NMR (D<sub>2</sub>O, 400 MHz) δ 9.47 (s, 1 H), 8.73 (s, 1 H), 8.69 (d, *J* = 8.6 Hz, 1 H), 8.61 (d, *J* = 5.6 Hz, 1 H), 8.10 (dd, *J* = 15, 6 Hz, 1 H), 7.98 (d, *J* = 9 Hz, 2 H), 7.41 (d, *J* = 9 Hz, 2 H), 3.80 (m, 2 H),  
15 3.01 (m, 2 H), 2.75 (m, 2 H), 2.28 (m, 4 H), 2.17 (m, 4 H), 2.03 (m, 2 H), 1.79 (m, 4 H); MS (ESI) 457 *m/z* (M<sup>+</sup>+1).

### Pharmaceutical compositions

According to one aspect of the present invention there is provided a pharmaceutical  
20 composition comprising a compound of formula I, as a free base or a pharmaceutically acceptable salt, solvate or solvate of salt thereof, for use in the prevention and/or treatment of conditions associated with glycogen synthase kinase-3.

The composition may be in a form suitable for oral administration, for example as a tablet,  
25 for parenteral injection as a sterile solution or suspension. In general the above compositions may be prepared in a conventional manner using pharmaceutically carriers or diluents. Suitable daily doses of the compounds of formula I in the treatment of a mammal, including man, are approximately 0.01 to 250 mg/kg bodyweight at peroral administration and about 0.001 to 250 mg/kg bodyweight at parenteral administration. The typical daily  
30 dose of the active ingredients varies within a wide range and will depend on various factors such as the relevant indication, the route of administration, the age, weight and sex of the patient and may be determined by a physician.



A compound of formula I, or a pharmaceutically acceptable salt, solvate or solvate of salt thereof, can be used on its own but will usually be administered in the form of a pharmaceutical composition in which the formula I compound/salt/solvate (active  
5 ingredient) is in association with a pharmaceutically acceptable diluent or carrier.

Dependent on the mode of administration, the pharmaceutical composition may comprise from 0.05 to 99 %w (per cent by weight), for example from 0.10 to 50 %w, of active ingredient, all percentages by weight being based on total composition.

10 A diluent or carrier includes water, aqueous polyethylene glycol, magnesium carbonate, magnesium stearate, talc, a sugar (such as lactose), pectin, dextrin, starch, tragacanth, microcrystalline cellulose, methyl cellulose, sodium carboxymethyl cellulose or cocoa butter.

15 A composition of the invention can be in tablet or injectable form. The tablet may additionally comprise a disintegrant and/or may be coated (for example with an enteric coating or coated with a coating agentsuch as hydroxypropyl methylcellulose).

The invention further provides a process for the preparation of a pharmaceutical  
20 composition of the invention which comprises mixing a compound of formula I, or a pharmaceutically acceptable salt, solvate or solvate of salt thereof, a hereinbefore defined, with a pharmaceutically acceptable diluent or carrier.

An example of a pharmaceutical composition of the invention is an injectable solution  
25 containing a compound of the invention, or a a pharmaceutically acceptable salt, solvate or solvate of salt thereof, as hereinbefore defined, and sterile water, and, if necessary, either sodium hydroxide or hydrochloric acid to bring the pH of the final composition to about pH 5, and optionally a surfactant to aid dissolution.

30 Liquid solution comprising a compound of formula I, or a salt thereof, dissolved in water.

<u>Solution</u>	<u>mg/mL</u>
Compound X	5.0% w/v
Pure water	To 100%

### Medical use

Surprisingly, it has been found that the compounds defined in the present invention, as a  
5 free base or a pharmaceutically acceptable salt thereof, are well suited for inhibiting  
glycogen synthase kinase-3 (GSK3). Accordingly, the compounds of the present invention  
are expected to be useful in the prevention and/or treatment of conditions associated with  
glycogen synthase kinase-3 activity, i.e. the compounds may be used to produce an  
inhibitory effect of GSK3 in mammals, including man, in need of such prevention and/or  
10 treatment.

GSK3 is highly expressed in the central and peripheral nervous system and in other tissues.  
Thus, it is expected that compounds of the invention are well suited for the prevention  
and/or treatment of conditions associated with glycogen synthase kinase-3 in the central  
15 and peripheral nervous system. In particular, the compounds of the invention are expected  
to be suitable for prevention and/or treatment of conditions associated with especially,  
dementia, Alzheimer's Disease, Parkinson's Disease, Frontotemporal dementia  
Parkinson's Type, Parkinson dementia complex of Guam, HIV dementia, diseases with  
associated neurofibrillar tangle pathologies and dementia pugilistica.

20 Other conditions are selected from the group consisting of amyotrophic lateral sclerosis,  
corticobasal degeneration, Down syndrome, Huntington's Disease, postencephalic  
parkinsonism, progressive supranuclear palsy, Pick's Disease, Niemann-Pick's Disease,  
stroke, head trauma and other chronic neurodegenerative diseases, Bipolar Disease,  
25 affective disorders, depression, schizophrenia, cognitive disorders, hair loss and  
contraceptive medication.

Further conditions are selected from the group consisting of predemented states, Mild  
Cognitive Impairment, Age-Associated Memory Impairment, Age-Related Cognitive  
Decline, Cognitive Impairment No Dementia, mild cognitive decline, mild neurocognitive

decline, Late-Life Forgetfulness, memory impairment and cognitive impairment, vascular dementia, dementia with Lewy bodies, Frontotemporal dementia and androgenetic alopecia and Type I and Type II diabetes, diabetic neuropathy and diabetes related disorders.

- 5 One embodiment of the invention relates to the prevention and/or treatment of dementia and Alzheimer's Disease.

The dose required for the therapeutic or preventive treatment of a particular disease will necessarily be varied depending on the host treated, the route of administration  
10 and the severity of the illness being treated.

The present invention relates also to the use of a compound of formula I as defined hereinbefore, in the manufacture of a medicament for the prevention and/or treatment of conditions associated with glycogen synthase kinase-3.

15 In the context of the present specification, the term "therapy" also includes "prevention" unless there are specific indications to the contrary. The terms "therapeutic" and "therapeutically" should be construed accordingly.

- 20 The invention also provides for a method of treatment and/or prevention of conditions associated with glycogen synthase kinase-3 comprising administering to a mammal, including man in need of such treatment and/or prevention a therapeutically effective amount of a compound of formula I, as hereinbefore defined.

#### **Non-medical use**

- 25 In addition to their use in therapeutic medicine, the compounds of formula I as a free base or a pharmaceutically acceptable salt thereof, are also useful as pharmacological tools in the development and standardisation of *in vitro* and *in vivo* test systems for the evaluation of the effects of inhibitors of GSK3 related activity in laboratory animals such as cats, dogs, rabbits, monkeys, rats and mice, as part of the search for new therapeutics agents.

## Pharmacology

### *Determination of ATP competition in Scintillation Proximity GSK3 $\beta$ Assay.*

#### *GSK3 $\beta$ scintillation proximity assay.*

- 5 The competition experiments were carried out in duplicate with 10 different concentrations of the inhibitors in clear-bottom microtiter plates (Wallac, Finland). A biotinylated peptide substrate, Biotin-Ala-Ala-Glu-Glu-Leu-Asp-Ser-Arg-Ala-Gly-Ser(PO<sub>3</sub>H<sub>2</sub>)-Pro-Gln-Leu (AstraZeneca, Lund), was added at a final concentration of 1  $\mu$ M in an assay buffer containing 1 mU recombinant human GSK3 $\beta$  (Dundee University, UK), 12 mM
- 10 morpholinepropanesulfonic acid (MOPS), pH 7.0, 0.3 mM EDTA, 0.01 %  $\beta$ -mercaptoethanol, 0.004 % Brij 35 (a natural detergent), 0.5 % glycerol and 0.5  $\mu$ g BSA/25  $\mu$ l. The reaction was initiated by the addition of 0.04  $\mu$ Ci [ $\gamma$ -<sup>33</sup>P]ATP (Amersham, UK) and unlabelled ATP at a final concentration of 1  $\mu$ M and assay volume of 25  $\mu$ l. After incubation for 20 minutes at room temperature, each reaction was terminated by the
- 15 addition of 25  $\mu$ l stop solution containing 5 mM EDTA, 50  $\mu$ M ATP, 0.1 % Triton X-100 and 0.25 mg streptavidin coated Scintillation Proximity Assay (SPA) beads (Amersham, UK). After 6 hours the radioactivity was determined in a liquid scintillation counter (1450 MicroBeta Trilux, Wallac). The inhibition curves were analysed by non-linear regression using GraphPad Prism, USA. The K<sub>m</sub> value of ATP for GSK3 $\beta$ , used to calculate the
- 20 inhibition constants (K<sub>i</sub>) of the various compounds, was 20  $\mu$ M.

The following abbreviations have been used:

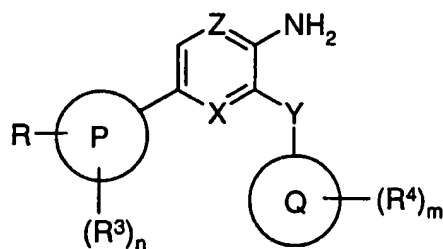
- |        |                                 |
|--------|---------------------------------|
| MOPS   | Morpholinepropanesulfonic acid  |
| EDTA   | Ethylenediaminetetraacetic acid |
| 25 BSA | Bovin Serum Albumin             |
| ATP    | Adenosine Triphosphate          |
| SPA    | Scintillation Proximity Assay   |
| GSK3   | Glycogen synthase kinase 3      |

*Results*

Typical  $K_i$  values for the compounds of the present invention are in the range of about 0.001 to about 10,000 nM. Other values for  $K_i$  are in the range of about 0.001 to about 1000 nM. Further values for  $K_i$  are in the range of about 0.001 nM to about 300 nM.

## CLAIMS

1. A compound having the formula I



wherein:

Z is N;

10 Y is CONR<sup>5</sup>, NR<sup>5</sup>CO, SO<sub>2</sub>NR<sup>5</sup>, NR<sup>5</sup>SO<sub>2</sub>, CH<sub>2</sub>NR<sup>5</sup>, NR<sup>5</sup>CH<sub>2</sub>, NR<sup>5</sup>CONR<sup>5</sup>, C<sub>1-6</sub>alkylene, CH<sub>2</sub>CO, COCH<sub>2</sub>, CH=CH, OCH<sub>2</sub> or CH<sub>2</sub>O;

X is CH or N;

15 P is phenyl or a 5 or 6 membered heteroaromatic ring containing one or more heteroatoms independently selected from N, O or S and said phenyl ring or heteroaromatic ring may optionally be fused with a 5 or 6 membered saturated, partially saturated or unsaturated ring containing one or more atoms selected from C, N, O or S;

20 Q is phenyl or a 5 or 6 membered heteroaromatic ring containing one or more nitrogen atoms and said phenyl ring or heteroaromatic ring may optionally be fused with a 5 or 6 membered saturated, partially saturated or unsaturated ring containing one or more atoms selected from C, N, O or S;

25 R is C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup> or C<sub>1-6</sub>alkylazetidine which azetidine ring may be optionally substituted by A;

R<sup>3</sup> and R<sup>4</sup> are independently selected from halo, nitro, CHO, C<sub>0-6</sub>alkylCN, OC<sub>1-6</sub>alkylCN, C<sub>0-6</sub>alkylOR<sup>6</sup>, OC<sub>1-6</sub>alkylOR<sup>6</sup>, fluoromethyl, difluoromethyl, trifluoromethyl, fluoromethoxy, difluoromethoxy, trifluoromethoxy, C<sub>0-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylOC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>OR<sup>7</sup> C<sub>0-6</sub>alkylCO<sub>2</sub>R<sup>6</sup>, OC<sub>1-6</sub>alkylCO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(CO)R<sup>7</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(CO)R<sup>7</sup>, O(CO)NR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>(CO)OR<sup>7</sup>, NR<sup>6</sup>(CO)NR<sup>6</sup>R<sup>7</sup>, O(CO)OR<sup>6</sup>, O(CO)R<sup>6</sup>, C<sub>0-6</sub>alkylCOR<sup>6</sup>, OC<sub>1-6</sub>alkylCOR<sup>6</sup>, NR<sup>6</sup>(CO)(CO)R<sup>6</sup>, NR<sup>6</sup>(CO)(CO)NR<sup>6</sup>R<sup>7</sup>, SR<sup>6</sup>, C<sub>0-6</sub>alkyl(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(SO<sub>2</sub>)R<sup>7</sup>, OC<sub>0-6</sub>alkyl(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, C<sub>0-6</sub>alkyl(SO)NR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkyl(SO)NR<sup>6</sup>R<sup>7</sup>, SO<sub>3</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, C<sub>0-6</sub>alkylNR<sup>6</sup>(SO)R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>(SO)R<sup>7</sup>, OC<sub>0-6</sub>alkylSO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylSO<sub>2</sub>R<sup>6</sup>, C<sub>0-6</sub>alkylSOR<sup>6</sup>, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl, wherein any C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl may be optionally substituted by one or more A;

m is 0, 1, 2, 3 or 4;

n is 0, 1, 2, 3 or 4;

R<sup>5</sup> is hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl, C<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup> or C<sub>1-6</sub>alkylCONR<sup>6</sup>R<sup>7</sup>;

R<sup>6</sup> and R<sup>7</sup> are independently selected from hydrogen, C<sub>1-6</sub>alkyl, (CO)OR<sup>8</sup>, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl and C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>;

R<sup>6</sup> and R<sup>7</sup> may together form a substituted 5 or 6 membered heterocyclic ring containing one or more heteroatoms independently selected from N, O or S, which heterocyclic ring may be optionally substituted by A;

R<sup>8</sup> and R<sup>9</sup> are independently selected from hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl and C<sub>0-6</sub>alkylheteroaryl;

R<sup>8</sup> and R<sup>9</sup> may together form a 5 or 6 membered heterocyclic ring containing one or more heteroatoms independently selected from N, O or S, which heterocyclic ring may be optionally substituted by A;

- 5 R<sup>10</sup> is hydrogen, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl or C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>;

R<sup>11</sup> is C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl;

- 10 A is halo, nitro, CHO, CN, OR<sup>6</sup>, C<sub>1-6</sub>alkyl, C<sub>2-6</sub>alkenyl, C<sub>2-6</sub>alkynyl, C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl, fluoromethyl, difluoromethyl, trifluoromethyl, fluoromethoxy, difluoromethoxy, trifluoromethoxy, C<sub>0-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, OC<sub>1-6</sub>alkylNR<sup>6</sup>R<sup>7</sup>, CO<sub>2</sub>R<sup>8</sup>, CONR<sup>6</sup>R<sup>7</sup>, NR<sup>6</sup>(CO)R<sup>6</sup>, O(CO)R<sup>6</sup>, COR<sup>6</sup>, SR<sup>6</sup>, (SO<sub>2</sub>)NR<sup>6</sup>R<sup>7</sup>, (SO)NR<sup>6</sup>R<sup>7</sup>, SO<sub>3</sub>R<sup>6</sup>, SO<sub>2</sub>R<sup>6</sup> or SOR<sup>6</sup>;

- 15 as a free base or a pharmaceutically acceptable salt, solvate or solvate of salt thereof.

2. A compound according to claim 1, wherein Z is N; Y is CONR<sup>5</sup>; X is N; P is phenyl; Q is a 6 membered aromatic heterocyclic ring containing one nitrogen atom; R is C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup>; m is 0; n is 0; R<sup>5</sup> is hydrogen; R<sup>10</sup> is hydrogen or C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl; C<sub>0-6</sub>alkylaryl, C<sub>0-6</sub>alkylheteroaryl or C<sub>1-6</sub>alkylNR<sup>8</sup>R<sup>9</sup>; and R<sup>11</sup> is C<sub>0-6</sub>alkylC<sub>3-6</sub>cycloalkyl.
- 20

3. A compound according to claim 2, wherein C<sub>1-6</sub>alkyl in C<sub>1-6</sub>alkylNR<sup>10</sup>R<sup>11</sup> represents propyl; R<sup>10</sup> and R<sup>11</sup> represents cyclobutyl; and Q represents pyridin.

25

4. A compound which is:

3-Amino-6-{4-[3-(dicyclobutylamino)propyl]phenyl}-N-pyridin-3-ylpyrazine-2-carboxamide hydrochloride;

as a free base or an alternative pharmaceutically acceptable salt, solvate or solvate of salt thereof

30

5. A compound which is:



3-Amino-6-bromo-*N*-pyridin-3-ylpyrazine-2-carboxamide;

as a free base, a salt, solvate or solvate of a salt thereof.

5

6. A compound which is:

*N*-[3-(4-Bromophenyl)propyl]-*N,N*-dicyclobutylamine;

as a free base, a salt, solvate or solvate of a salt thereof.

10

7. A pharmaceutical formulation comprising as active ingredient a therapeutically effective amount of a compound according to any one of claims 1 to 4 in association with pharmaceutically acceptable carriers or diluents.

15

8. The pharmaceutical formulation according to claim 7 for use in the prevention and/or treatment of conditions associated with glycogen synthase kinase-3.

9. A compound as defined in any one of claims 1 to 4 for use in therapy.

20

10. Use of a compound according to any one of claims 1 to 4 in the manufacture of a medicament for prevention and/or treatment of conditions associated with glycogen synthase kinase-3.

25

11. Use of a compound according to any one of claims 1 to 4 in the manufacture of a medicament for prevention and/or treatment of dementia, Alzheimer's Disease, Parkinson's Disease, Frontotemporal dementia Parkinson's Type, Parkinson dementia complex of Guam, HIV dementia, diseases with associated neurofibrillar tangle pathologies and dementia pugilistica.

30

12. Use of a compound according to claim 11, wherein the disease is Alzheimer's Disease.

13. Use of a compound according to any one of claims 1 to 4 in the manufacture of a medicament for prevention and/or treatment of amyotrophic lateral sclerosis, corticobasal degeneration, Down syndrome, Huntington's Disease, postencephalatic parkinsonism,

35

progressive supranuclear palsy, Pick's Disease, Niemann-Pick's Disease, stroke, head trauma and other chronic neurodegenerative diseases, Bipolar Disease, affective disorders, depression, schizophrenia, cognitive disorders, hair loss and contraceptive medication.

5 14. Use of a compound according to any one of claims 1 to 4 in the manufacture of a medicament for prevention and/or treatment of predemented states, Mild Cognitive Impairment, Age-Associated Memory Impairment, Age-Related Cognitive Decline, Cognitive Impairment No Dementia, mild cognitive decline, mild neurocognitive decline, Late-Life Forgetfulness, memory impairment and cognitive impairment, vascular  
10 dementia, dementia with Lewy bodies, Frontotemporal dementia and androgenetic alopecia and Type I and Type II diabetes, diabetic neuropathy and diabetes related disorders.

15 15. A method of prevention and/or treatment of conditions associated with glycogen synthase kinase-3, comprising administering to a mammal, including man in need of such prevention and/or treatment, a therapeutically effective amount of a compound of formula I as defined in any one of claims 1 to 4.

16. A method of prevention and/or treatment of dementia, Alzheimer's Disease, Parkinson's Disease, Frontotemporal dementia Parkinson's Type, Parkinson dementia complex of Guam, HIV dementia, diseases with associated neurofibrillar tangle  
20 pathologies and dementia pugilistica, comprising administering to a mammal, including man in need of such prevention and/or treatment, a therapeutically effective amount of a compound of formula I as defined in any one of claims 1 to 4.

25 17. The method according to claim 16, wherein the disease is Alzheimer's Disease.

18. A method of prevention and/or treatment of amyotrophic lateral sclerosis, corticobasal degeneration, Down syndrome, Huntington's Disease, postencephalatic parkinsonism, progressive supranuclear palsy, Pick's Disease, Niemann-Pick's Disease, stroke, head trauma and other chronic neurodegenerative diseases, Bipolar Disease, affective disorders,  
30 depression, schizophrenia, cognitive disorders, hair loss and contraceptive medication, comprising administering to a mammal, including man in need of such prevention and/or

treatment, a therapeutically effective amount of a compound of formula I as defined in any one of claims 1 to 4.

19. A method of prevention and/or treatment of predemented states, Mild Cognitive  
5 Impairment, Age-Associated Memory Impairment, Age-Related Cognitive Decline,  
Cognitive Impairment No Dementia, mild cognitive decline, mild neurocognitive decline,  
Late-Life Forgetfulness, memory impairment and cognitive impairment, vascular  
dementia, dementia with Lewy bodies, Frontotemporal dementia and androgenetic alopecia  
and Type I and Type II diabetes, diabetic neuropathy and diabetes related disorders,  
10 comprising administering to a mammal, including man in need of such prevention and/or  
treatment, a therapeutically effective amount of a compound of formula I as defined in any  
one of claims 1 to 4.

20. The use of the intermediates according to claim 5 or 6 for the preparation of a  
15 compound of formula I as defined in any one of claims 1 to 4.

**INTERNATIONAL SEARCH REPORT**International application No.  
PCT/SE 2003/001955**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 16-19  
because they relate to subject matter not required to be searched by this Authority, namely:  
**See extra sheet**
2. ☒ Claims Nos.: 8, 10 (partially)  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:  
**See extra sheet**
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

**See extra sheet**

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-4, 7-19

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE 2003/001955

## Box II.1

Claims 16-19 relate to methods of treatment of the human or animal body by surgery or by therapy or diagnostic methods practiced on the human or animal body (Rule 39.1(iv)). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds or compositions.

## Box II.2

The expression "conditions associated with glycogen synthase kinase-3" in claims 8 and 10 is not clear and concise and does not comply with PCT Articles 5 and 6 as it defines the conditions by the mechanism behind the conditions and does not mention the specific conditions. It is therefore not clear which conditions are comprised by these claims. The search has been performed on the general expression in some parts but has mainly been focused on the conditions named in claims 11-14.

## Box III

According to PCT Article 34 (3) (a-c) and Rule 13.2, an application shall relate to one invention only or to a group of inventions linked by one or more of the same or corresponding "special technical features", i.e. features that define a contribution which each of the inventions makes over the prior art. In order to consider that end products and intermediates represents one invention it is necessary that the essential structural elements of the end product also can be found in the intermediate. Claims 5-6 and 20 of the present application relates to intermediates and their use. These compounds are not considered to have enough structural similarity with the end products to fulfil the demands of unity. The compounds defined of the application have been divided into three inventions according to the following:

- 1) Compounds according to formula I. Pharmaceutical formulations, use and methods involving these compounds. Claims 1-4 and 7-19.
- 2) The compound 3-amino-6-bromo-*N*-pyridin-3-ylpyrazine-2-carboxamide and use of this compound. Claims 5 and 20 partially.
- 3) The compound *N*-[3-(4-bromophenyl)propyl]-*N,N*-dicyclobutylamine and use of this compound. Claims 6 and 20 partially.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE 2003/001955

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07D 401/12, C07D 401/14, A61K 31/497, A61P 25/00, A61P 3/10, A61P 5/48, A61P 15/18, A61P 17/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07D, A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CHEM ABSDATA, WPI DATA, EPO-INTERNAL

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0168612 A2 (COCENSYS, INC.), 20 Sept 2001 (20.09.2001) --	1-4,7-19
X	US 2001/0031772 A (KARL SCHOENAFINGER ET AL), 18 October 2001 (18.10.2001) --	1-4,7-19
A	WO 02092585 A1 (BIOVITRUM AB), 21 November 2002 (21.11.2002) --	1-4,7-19
A	WO 0160806 A2 (NEUROGEN CORPORATION), 23 August 2001 (23.08.2001) --	1-4,7-19

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

\* Special categories of cited documents

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 April 2004

Date of mailing of the international search report

20-04-2004

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE 2003/001955

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6255307 B1 (BRIAN COX ET AL), 3 July 2001 (03.07.2001)  -- -----	1-4, 7-19

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

31/03/2004

International application No.

PCT/SE 2003/001955

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INTERNATIONAL SEARCH REPORT  
Information on patent family members

31/03/2004

International application No.

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